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16 March 2000

BOEING

Mr. Jerome Johnson
U.S. EPA
Region VII
901 North Fifth Street
Kansas City, Kansas 66101

Enclosure: RCRA Facility Investigation Workplan Addendum for **McDonnell Douglas Tract I**

Dear Mr. Johnson;

McDonnell Douglas (a wholly owned subsidiary of The Boeing Company) is submitting the enclosed RCRA Facility Investigation Workplan Addendum for Solid Waste Management Unit # 17. Two copies of the workplan addendum will also be sent to Mr. Fuad Marmash of the Missouri Department of Natural Resources. The focused work plan, for addressing units at the Building 27 Naval Weapons Industrial Reserve Plant, identified in the Navy Environmental Baseline Survey for Transfer will be submitted separately.

Please contact me should you have any questions or need additional assistance.

Sincerely,

Joseph Haake

Joseph W. Haake. Group Manager
Environmental and Hazardous Materials Services
Dept. 464C, Bldg. 220, Mailcode S221-1400
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RCRA Facility Investigation Workplan Addendum for McDonnell Douglas Hazelwood, Missouri Facility

Prepared for:
McDonnell Douglas
(a wholly owned subsidiary of The Boeing Company)
St. Louis, Missouri

Prepared by:
Environmental Science & Engineering, Inc.
St. Louis, Missouri

March 16, 2000

ESE Project No. 5197-042-0600

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1.0 INTRODUCTION

This document represents the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Workplan Addendum for Corrective Action activities to be conducted for Solid Waste Management Unit (SWMU) No. 17 at the McDonnell Douglas facility. McDonnell Douglas is now a wholly owned subsidiary of The Boeing Company (Boeing). The Tract I facility (Facility) is located in Hazelwood, Missouri. The Facility location is presented in Figure 1-1.

This RFI Workplan Addendum supplements the previously approved RFI Workplan that was submitted to the Missouri Department of Natural Resources (MDNR) on November 24, 1997. This document fully complies with the Corrective Action requirements of the Facility's Part B Permit.

1.1 Purpose

The RFI Workplan Addendum presents the supplemental planned approach for characterizing the nature of any hazardous waste/constituent releases to soil or groundwater from SWMU No. 17. Figure 1-2 displays significant features of the Facility and the locations of the SWMUs that are being investigated in the RFI.

This document and the previously approved support plans will provide MDNR personnel with Boeing's proposed technical scope of work and administrative/implementation approach for completion of RFI investigation and reporting activities. Upon review and formal approval by MDNR, this Workplan Addendum will serve as the planning document for the supplemental field investigation of SWMU No. 17. The field investigation component of the Workplan Addendum will be utilized in conjunction with two associated support plans including a Quality Assurance Project Plan (QAPP) and a Health and Safety Plan (HASP) which were previously approved by MDNR.

1.2 Workplan Addendum Organization

This Workplan Addendum is divided into eight sections of text. A brief description of each section is presented below.

Section 1.0, Introduction, describes the purpose and content of this Workplan Addendum.

Section 2.0, Project Management, references the various management and administrative issues associated with the project.

Section 3.0, Supplemental Investigation Approach, summarizes the RFI findings to date for SWMU No. 17 and presents the planned sample collection/analysis approach for the supplemental field activities at the unit.

Section 4.0, Sampling and Analysis Procedures, describes the procedures to be implemented for all field sampling and laboratory analysis activities.

Section 5.0, Evaluation of Investigation Results, describes the development, tracking, evaluation, and presentation of investigative data.

Section 6.0, Quality Assurance/Quality Control, references the quality assurance and quality control measures to be implemented for all data collection activities.

Section 7.0, Health and Safety, references the health and safety procedures to be utilized for all field investigation activities.

Section 8.0, References, provides a list of references that were used in the development of this Workplan Addendum document.

2.0 PROJECT MANAGEMENT

The overall project management approach for the Boeing RFI is detailed in the previously approved RFI Workplan dated November 24, 1997. Project management modifications are summarized below.

2.1 Updated Schedule

The revised work schedule for completion of the Boeing RFI program is presented in Figure 2-1. Duration of MDNR review processes, which control the start date of mobilization and field activities, has been estimated based upon conversations between MDNR and Boeing personnel. It is anticipated that the final schedule may require modification based upon the actual review/approval process, as well as existing weather conditions at the time of MDNR approval and throughout the investigation.

2.2 Project Organization and Personnel

All of the Boeing and ESE supervisory personnel identified in the November 1997 RFI Workplan remain the same.

Subcontractors

With the approval of Boeing's Project Manager, ESE will utilize either Quanterra Environmental Services (North Canton, Ohio) or TestAmerica, Inc. (Nashville, TN) to complete the required off-site laboratory analyses. Both laboratories possess the capability to perform the required analytical methods and the associated QA/QC back-up data. Once the supplemental scope of work is finalized, Boeing will evaluate cost quotations from both labs before making a final selection.

Similarly, ESE will utilize the services of Petro-Probe Investigations, Inc. (St. Louis) and Roberts Drilling (Columbia, IL) to complete the required soil borings and monitoring well installation efforts. Both firms maintain experienced, licensed personnel who maintain the required OSHA health and safety training certifications. ESE will provide overall project management, coordination, and quality control of subcontractor activities in accordance with the RFI Workplan objectives.

3.0 SUPPLEMENTAL INVESTIGATION APPROACH

This section of the RFI Workplan Addendum describes the approach that will be utilized to conduct the supplemental investigation of SWMU No. 17. Findings from prior investigations are initially summarized to establish the basis for this supplemental field investigation. Recommended approaches for sampling and analysis are then provided along with supporting rationale to characterize the nature and extent of any potential hazardous waste/constituent releases to soil or groundwater at this unit.

3.1 RFA Findings

Limited soil sampling activities were conducted as part of the RFA to preliminarily assess whether any releases have occurred from this unit. Two shallow soil samples (0-12 inches bls and 12-24 inches bls) were collected from one soil boring for off-site laboratory analysis.

Four VOC constituents including PCE (760 to 290,000 μg/kg), acetone (88 to 140 μg/kg), total xylenes (11 to 32 μg/kg), and 1,2-dichloroethene (1,2-DCE) (14 to 44 μg/kg) were detected in the samples and sample duplicates acquired from this unit. The shallower sample exhibited the highest PCE concentration of 290,000 μg/kg, while the field duplicate for the same depth interval exhibited a lower PCE concentration of 40,000 μg/kg.

Inorganic constituents were detected in the samples acquired from this unit. However, arsenic and selenium represent the only inorganic constituents which exceeded USGS-based regional background levels. Arsenic was detected in the deeper sample at a concentration of 46.3 mg/kg, while selenium was detected in the shallower sample at a concentration of 4.02 mg/kg.

3.2 RFI Findings to Date

Geological soil boring data, analytical soil data, analytical groundwater data, groundwater elevation measurements, and various field data have been utilized to characterize the nature and extent of any hazardous waste/constituent impacts from SWMU No. 17.

3.2.1 Geological Cross-Section for SWMU No. 17

Based on the available RFI soil boring data for SWMU No. 17, a geological cross-section was prepared to illustrate subsurface characteristics at this unit. The cross-section depicts the relationships between various geologic units.

Geological Interpretations

The following conclusions were based on a review of the referenced cross-section:

- The Fill Unit beneath SWMU No. 17 extends from at/near the surface to a depth of approximately 2-5 ft bls.
- The Silty Clay Unit is encountered beneath the Fill Unit and exhibits a typical thickness of approximately 12-15 ft.;
- The Clay Unit is encountered at approximately 17 ft bls; and
- SWMU No. 17 is underlain by an apparently continuous, homogeneous lacustrine clay of undetermined total thickness.

Hydrogeological Interpretations

The following conclusions were based on a review of the referenced cross-section:

- Present across the Facility and including SWMU No. 17, the continuity and thickness of the Clay Unit are verified. The low vertical permeability of this Clay Unit provides a degree of vertical hydraulic separation from the underlying bedrock.
- Based on the relatively flat elevations displayed in the cross-section, stratigraphical contours are not anticipated to significantly alter constituent migration patterns.

3.2.2 Analytical Results for SWMU No. 17 Soil Samples

Analytical results for SWMU No. 17 soil samples were utilized to assess the horizontal and vertical extent of any impacted soils at this unit.

Ten (10) total borings were advanced to assess the extent of any releases from SWMU No. 17. Several of the soil borings exhibited PID/visual evidence of VOC-related impacts, thus necessitating the completion of additional "step-out" borings. At these locations, the impacted boring was plugged and a new boring was advanced at a location of 20-30 ft further away from the source area. In this manner, the horizontal extent of SWMU No. 17 was extended further in an easternly direction.

Soil samples were collected from each of the borings and submitted for chemical analysis to delineate the horizontal extent of SWMU No. 17. Eleven (11) VOC constituents including perchloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), 1,1,2-trichloroethane, acetone, methylene chloride, 2-butanone, toluene, xylenes, and ethylbenzene were detected in samples acquired from this area. The highest VOC concentrations were detected at soil borings SB-1, SB-2, SB-3, and SB-4 within the most interior portions of the unit. Soil samples from SB-4, SB-1, and SB-2 exhibited the highest PCE concentrations of 240 ppm, 58 ppm, and 18 ppm, respectively. Soil samples from SB-4 and SB-1 contained 11.9 ppm and 3.2 ppm cis-1,2-DCE, respectively. Soil samples from SB-7 along the southwest portion of the area and SB-5 along the northeast portion of the area exhibited PCE concentrations of 4.2 ppm and 3.6 ppm, respectively.

Although collected from saturated intervals, soil samples from a deeper boring (SB-9) were also analyzed. While PCE was not detected in any of the SB-9 samples, several other VOC constituents were detected. Saturated soil samples from SB-9 exhibited maximum concentrations of 12 ppm TCE and 0.38 ppm 1,1,2-trichloroethane.

Eighteen (18) of the twenty five soil samples collected from SWMU No. 17 contained concentrations which exceeded at least one VOC ITL. Six VOC constituents exceeded ITLs (cis-1,2-DCE, trans-1,2-DCE, methylene chloride, perchloroethene, 1,1,2-trichloroethane, and TCE).

Soil samples from SB-5 and SB-6 to the northeast of SWMU No. 17 were also analyzed for other non-RCRA related parameters. One soil sample from SB-5 exhibited a gasoline range organics (GRO) concentration of 180 ppm and a total extractable hydrocarbons (TPH) concentration of 1,900 ppm. One soil sample from SB-6 exhibited GRO and TPH levels of 25 ppm and 450 ppm, respectively.

Seven of eight heavy metal constituents were detected for samples acquired from SWMU No. 17. Concentrations were comparable to background values. Maximum concentrations for the unit included 20 ppm arsenic, 310 ppm barium, 0.9 ppm cadmium, 22 ppm chromium, 16 ppm lead, 0.56 ppm mercury, and 1.6 ppm selenium. None of the soil samples from SWMU No. 17 contained constituent concentrations which exceeded metals ITLs.

The maximum detected values for the SWMU No. 17 soil samples were compared to the constituent-specific ITL values to evaluate the presence of significant constituent concentrations. Six (6) VOC constituents exceeded the corresponding ITL values for soils. In addition, three other VOCs (benzene, 1,1-DCE, and vinyl chloride) exceeded the corresponding ITL values for groundwater. As a result, the following COCs at SWMU No. 17 have been retained for further evaluation:

- VOCs (9): benzene, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,2-trichloroethane, TCE, vinyl chloride, and methylene chloride.

3.2.3 Analytical Results for SWMU No. 17 Groundwater Samples

Analytical results for SWMU No. 17 groundwater samples were utilized to characterize the nature and extent of constituent releases to groundwater beneath this unit.

Six groundwater samples were collected from SWMU No. 17 for chemical analysis. Groundwater samples from four of the temporary piezometers (TP-1, TP-2, TP-3, and TP-4) and monitoring well MW-6S provided analytical data regarding shallow groundwater conditions. The groundwater sample acquired from MW-5I was used to characterize groundwater conditions from an intermediate portion of the saturated unit.

Fourteen (14) VOCs were detected in groundwater samples collected from SWMU No. 17. Three of the sampling locations which exhibited the highest VOC concentrations were situated within and immediately downgradient to the unit (TP-1, TP-2, and MW-5I). Groundwater samples from TP-1, TP-2, and MW-5I exhibited the highest total VOC concentrations of 317 ppm, 58 ppm, and 146 ppm, respectively. The groundwater sample from TP-4 along the southwest corner of the unit also contained 17 ppm total VOCs. A downgradient boundary point was established to the northeast of SWMU No. 17 where no VOCs were detected from TP-3.

PCE and several degradation products including TCE and cis-1,2-DCE were detected at the highest concentrations. Groundwater samples from TP-1 and TP-2 exhibited the highest PCE concentrations of 210 ppm and 45 ppm, respectively. The sample from TP-1 also contained the highest cis-1,2-DCE level of 97 ppm. Located approximately 70 feet downgradient (east) from TP-1, the groundwater sample from intermediate well MW-5I exhibited the highest TCE concentration of 140 ppm.

Analytical results for the adjacent shallow and intermediate monitoring wells (MW-6S and MW-5I, respectively) were also compared. Detected VOCs for the two wells were similar. However, the TCE concentration for the intermediate well MW-5I (140 ppm) was significantly higher than the comparable value for MW-6S (0.37 ppm). In addition, vinyl chloride was detected only at these two SWMU No. 17 groundwater sampling locations. Groundwater samples from MW-5I and MW-6S exhibited vinyl chloride concentrations of 0.25 ppm and 0.94 ppm, respectively. Other VOC constituents including acetone, benzene, ethylbenzene, methylene chloride, toluene, and xylenes were generally detected at low concentrations, e.g. 50 ppb or less, and/or on an isolated basis. Detected levels for acetone and methylene chloride in particular are likely to be laboratory artifacts.

Five (5) metals including arsenic, barium, lead, mercury, and selenium were detected in the groundwater samples collected from TP-1 at SWMU No. 17. The groundwater sample exhibited detectable "total" levels of arsenic (0.0037 ppm), barium (0.44 ppm), and lead (0.0042 ppm). The sample exhibited detectable "dissolved" levels of barium (0.44 ppm), mercury (0.00034 ppm), and selenium (0.011 ppm). None of the metal constituent concentrations exceeded their respective ITLs.

The maximum concentration values were determined for the set of temporary piezometers/monitoring wells at SWMU No. 17. These maximum values for the groundwater samples were compared to the constituent-specific ITL values to evaluate the presence of significant constituent concentrations in groundwater. Although methylene chloride is potentially associated with laboratory carryover, it is also being retained for analysis in the upcoming supplemental investigation effort. As a result, the following groundwater-associated COCs at SWMU No. 17 have been retained for further evaluation:

- VOCs (9): benzene, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,2-trichloroethane, TCE, vinyl chloride, and methylene chloride.

3.2.4 Groundwater Field Measurements for SWMU No. 17

In addition to the collection of samples for laboratory analysis, groundwater samples were also evaluated for the following field parameters: pH, conductivity, and temperature. These results are summarized by parameter below.

pH values for SWMU No. 17 groundwater samples ranged from 6.2 to a high of 12.9. Most values generally ranged from pH 6.5 -7.5. The strongly basic value of 12.9 was detected from TP-4 to the southwest of the unit. This reading represents the only pH value which indicates the presence of potentially abnormal groundwater conditions.

Conductivity values for SWMU No. 17 groundwater samples ranged from 1,300 - 101,000 us/cm. Most values generally ranged from 1,300 - 14,500 us/cm. The high end value of 101,000 us/cm was detected from TP-4 to the southwest of the unit. This reading represents the only conductivity value which indicates the presence of potentially abnormal groundwater conditions.

Temperature values for SWMU No. 17 groundwater samples ranged from 8 - 17°C. The lowest values were recorded during the February monitoring events while the highest values were recorded during the April monitoring event. None of the temperature results indicates the presence of any abnormal groundwater conditions.

3.3 Overview of Sampling Approach

A biased sampling approach will be used to locate sampling locations in and around SWMU No. 17. The approximate locations, number of samples, and analyses have been determined using the following criteria:

- RFI soil boring and analytical results acquired in February, 1998 and April, 1998;
- RFA soil boring and analytical results;
- SWMU layout;
- hazardous wastes or hazardous constituents managed;
- field conditions (e.g. staining, cracks, obstructions); and
- historical operations or procedures performed at SWMU No. 17.

A discussion of the specific investigative approach for SWMU No. 17 is provided in the following subsection. The proposed sampling locations are approximate and subject to slight revision at the time of sampling, based on field observations and encountered conditions. Table 3-1 presents a summary of the supplemental investigation parameters for SWMU No. 17 including: number of borings, number of groundwater monitoring points, number of samples, target constituents, analytical methods, sample selection criteria, sample collection method, and projected minimum boring depth.

Subsurface soil/groundwater sampling and aquifer test methods will be conducted to further evaluate SWMU No. 17. In the event that the selected sampling method proves unsuitable at a specific location due to access restrictions, subsurface restrictions, or unsuitable soils, an alternate sampling method may be employed. Any alternate sampling methods must be capable of collecting representative samples in a manner which is consistent with the objectives of this Workplan Addendum. Due to the presence of buried utilities in the area, actual sampling locations will be determined through discussions with Boeing facilities personnel and confirmed in the field prior to sampling.

3.4 Sample Collection Plan

Based on the RFI findings to date, Boeing will complete the field investigation efforts described below to further delineate horizontal and vertical impacts beneath SWMU No. 17. Approximate locations for the new soil borings, monitoring wells, and the temporary piezometer are displayed in Figure 3-1.

3.4.1 Investigation of Downgradient Impacts

Three soil borings (SB-MW8S, SB-MW8I, SB-MW8D) will be located to the east of SWMU No. 17 for subsequent completion as monitoring wells (MW-8S, MW-8I, MW-8D). Most importantly, the proposed locations will help delineate the horizontal/vertical extent of VOC impacts to groundwater. Boeing's objective is to establish "clean" groundwater monitoring points (1 shallow, 1 intermediate, 1 deep) that will delineate the extent of any downgradient impacts. These locations will also serve to further delineate the horizontal and vertical extent of VOC impacts to soil outside of the source area.

Soil samples will be collected at selected intervals from each of the 3 soil borings. Based on an anticipated groundwater elevation of 8-10 ft bls, soil borings SB-MW8S, SB-MW8I, and SB-MW8D will be completed to respective depths of approximately 15 ft bls, 40 ft bls, and 70 ft bls.

With the objective of identifying "clean" soil verification samples, Boeing will collect and submit 3 representative soil samples from different depths for off-site analysis. (One 70-ft Geoprobe boring may be completed prior to initiating the 3 HSA borings to fulfill the sample collection requirements and enhance the efficiency of the monitoring well installation process.) Samples will be screened for off-site analysis utilizing appropriate field instrumentation including a photoionization detector (PID). The field geologist will also retain authority to select samples on the basis of visual/olfactory means. Selected samples will be properly labeled, packaged, and shipped off-site for laboratory analysis.

If detectable PID readings <u>are</u> encountered for any of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for off-site analysis. Furthermore, if evidence of PCE/VOC impacts is encountered at any of these 3 boring locations, an additional set of borings will be advanced at a location which is approximately 50 ft further east of the unit (hydraulically downgradient). This "step-out" process will be utilized to delineate the horizontal extent of potential VOC impacts, while minimizing the number of samples that are submitted for laboratory analysis. If unexpected field conditions are encountered, the ESE Field Implementation Manager will advise Boeing regarding any recommended changes in sampling approach.

The three HSA soil borings will be completed as a nested set of groundwater monitoring wells (MW-8S, MW-8I, and MW-8D). Following development and purging of these wells, groundwater samples will be collected from each of the wells and tested for oxidation/reduction potential and dissolved oxygen using appropriate field screening instrumentation. This field data will be useful in assessing the biodegradability of VOCs in groundwater at this unit.

Groundwater samples will subsequently be collected from each of these monitoring wells as part of a quarterly groundwater monitoring program. This monitoring program is described in Section 3.4.4.

3.4.2 Investigation of Suspected Source Area

Two shallow soil borings (SB-MW7S, SB-11) will be located within the source area of SWMU No. 17 for subsequent completion as groundwater monitoring points (MW-7S, TP-5). Soil boring SB-MW7S will facilitate the determination of various hydrogeological parameters in the shallow water-bearing unit and help determine the potential presence of any dense non-aqueous product layer (DNAPL). Soil boring SB-11 will be completed inside of Building 51 to further delineate the horizontal extent of any soil impacts in the unsaturated unit. These monitoring points will also be used as part of an short-term aquifer test to evaluate well drawdown and hydraulic communication characteristics.

Soil samples will be collected continuously from SB-11. Based on an anticipated groundwater elevation of 8-10 ft bls, soil borings SB-MW7S and SB-11 will each be completed to an approximate depth of 15 ft bls.

Samples will be screened for off-site analysis utilizing appropriate field instrumentation. If detectable PID readings are encountered for SB-11, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for off-site analysis. However, since soil impacts have already been characterized at SB-1 (likely to be within 5-10 ft of SB-MW7S), Boeing does not anticipate submitting any samples from SB-MW7S for off-site laboratory analysis. If unexpected field conditions are encountered, the ESE Field Implementation Manager will advise Boeing regarding any recommended changes in sampling approach.

Soil boring SB-MW7S will be completed as a groundwater monitoring well (MW-7S), while SB-11 will be completed as a temporary piezometer (TP-5). Following development, field screening procedures (interface probe measurements and visual observation) will be performed to evaluate the potential presence of any DNAPL. If DNAPL is present, a sample will be collected and submitted for off-site analysis. Existing monitoring wells MW-5I and MW-6S will also be evaluated for potential DNAPL in a similar manner.

A short-term aquifer test will be conducted at MW-7S to evaluate well drawdown and hydraulic communication characteristics within the source area. This evaluation will be performed as a pump test if well recovery rates are sufficient. If not, a slug test may be utilized. Water level measurements will be recorded for MW-7S, adjacent temporary piezometers (TP-1, TP-2, TP-5), and adjacent monitoring wells (MW-5I, MW-6S). If DNAPL is detected at MW-7S, the ESE Field Implementation Manager will retain authority to conduct the aquifer test at a different well location. Aquifer test procedures are described in Section 4.8.

Groundwater samples will also be collected from monitoring well MW-7S and temporary piezometer TP-5 as part of the quarterly groundwater monitoring program. This monitoring program is described in Section 3.4.4.

3.4.3 Investigation of Upgradient Area

Two proposed soil borings (SB-MW9S, SB-MW9I) will be located to the southwest of SWMU No. 17 for subsequent completion as monitoring wells (MW-9S, MW-9I). The proposed locations will help delineate the horizontal and vertical extent of VOC impacts to groundwater. Boeing's objective is to establish "clean" groundwater monitoring points (1 shallow, 1 intermediate) that will verify the direction of groundwater flow across the unit and help evaluate the elevated pH/conductivity values that were detected at temporary piezometer TP-4.

Soil samples will be collected at selected intervals from each of the 2 soil borings. Based on an anticipated groundwater elevation of 15-20 ft bls in this particular area, soil borings SB-MW9S and SB-MW9I will be completed to respective depths of approximately 25 ft bls and 40 ft bls.

With the objective of identifying "clean" soil verification samples, Boeing will collect and submit 2 representative soil samples for off-site analysis. (One 40-ft Geoprobe boring may be completed prior to initiating the 2 HSA borings to fulfill the sample collection requirements and enhance the efficiency of the monitoring well installation process.) Samples will be screened for off-site analysis utilizing appropriate field instrumentation including a PID. The field geologist will also retain authority to select samples on the basis of visual/olfactory means. Selected samples will be properly labeled, packaged, and shipped off-site for laboratory analysis.

If detectable PID readings <u>are</u> encountered for either of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for off-site analysis. Furthermore, if evidence of PCE/VOC impacts is encountered at either of these 2 boring locations, an additional set of borings will be advanced at a feasible location that is approximately 50 ft further southwest of the unit. This "step-out" process will be utilized to delineate the horizontal extent of potential VOC impacts, while minimizing the number of samples that are submitted for laboratory analysis. If unexpected field conditions are encountered, the ESE Field Implementation Manager will advise Boeing regarding any recommended changes in sampling approach.

The two soil borings will be completed as a nested set of groundwater monitoring wells (MW-9S and MW-9I). Following development and purging of these wells, groundwater samples will be collected from each of the wells and tested for oxidation/reduction potential and dissolved oxygen using appropriate field screening instrumentation. This field data will be useful in assessing the biodegradability of VOCs in groundwater at this unit.

Groundwater samples will subsequently be collected from both of these monitoring wells as part of the quarterly groundwater monitoring program. This monitoring program is described in Section 3.4.4.

3.4.4 Quarterly Groundwater Monitoring Program

Boeing will initiate a quarterly groundwater monitoring program to document groundwater elevations across SWMU No. 17, delineate the horizontal/vertical extent of any VOC impacts to groundwater, and assess any associated temporal variations. Groundwater samples will initially be collected from each of the 7 monitoring wells and 5 temporary piezometers at SWMU No. 17 as part of the groundwater monitoring program. These samples will be evaluated for selected field criteria (temperature, pH, and conductivity) and then submitted for off-site analysis of selected VOCs. Three of these groundwater samples will also be submitted for off-site analysis of selected biodegradation parameters (total organic carbon [TOC], dissolved organic carbon, nitrate, nitrite, nitrate/nitrite as N, chloride, total iron, ferrous iron, and sulfate).

Following the completion of the initial monitoring event, analytical results will be evaluated to potentially refine the well locations and frequency for subsequent monitoring events. Groundwater elevation and field parameter measurements will continue to be performed for each of the four quarterly monitoring events. Following the completion of the fourth groundwater event, Boeing will evaluate the monitoring results and refine the program as necessary.

3.4.5 Sample Analysis Plan

As described in Sections 3.3.3 and 3.3.4, soil and groundwater samples will be selectively analyzed for nine VOCs (benzene, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,2-trichloroethane, TCE, vinyl chloride, and methylene chloride). This COC list includes the suspected source constituent (PCE), its potential degradation products, and other VOCs which exceeded ITL values for soil or groundwater media. Analyses will be performed in accordance with USEPA Method 8240.

In addition, soil samples from a downgradient soil boring location (SB-MW8D or the associated Geoprobe boring) will be analyzed for selected geotechnical (moisture content, soil bulk density, and grain size distribution) and biodegradation parameters. Three groundwater samples will also be submitted for off-site analysis of selected biodegradation parameters.

3.4.6 Sampling Re-Cap

Boeing anticipates that 7 soil borings (6 HSA and 1 Geoprobe) will be completed to further characterize the nature and extent of any impacts to soil at SWMU No. 17. Six (6) of these seven soil borings will be completed as monitoring wells, while the remaining point will be completed as a temporary piezometer. Approximate soil boring/monitoring well locations are displayed in Figure 3-1. Approximately 6 soil samples will be submitted for off-site laboratory analysis. Twelve (12) groundwater samples will be submitted for lab analysis as part of the initial quarterly groundwater monitoring event to delineate the extent of any VOC impacts to groundwater.

4.0 SAMPLING AND ANALYSIS PROCEDURES

This section describes the pertinent sample collection, monitoring well installation, laboratory analysis, and aquifer test procedures.

4.1 Direct Push Sampling Technology

4.1.1 Soil Sampling

Direct push/hydraulic soil probe (Geoprobe) subsurface sampling equipment will be utilized as the primary drilling methodology wherever site conditions permit its use. Geoprobe equipment will be mounted on a truck or all terrain vehicle (ATV) for subsurface investigations.

The hydraulic soil probe technology utilizes static and percussion forces to drive probing and sampling tools into the subsurface. The thin-walled soil sampling tube remains completely sealed as it is driven to the desired sampling depth by steel probing rods. An internal piston is then manually released allowing soil to enter the sampling tube, which is lined with a disposable polybutylate (acetate) liner. The sampling tube is then driven further to collect the soil from the desired depth interval. The sampling tube is withdrawn and the polybutylate-encased sample is removed from the sampling tube.

An aliquot of sample will be placed directly into the appropriate sample container from each sampling location. No compositing of samples shall be performed. The samples collected for VOC analysis will be filled to the top of the jar to minimize the amount of headspace in the jar which may result in the loss of volatile compounds from the sample. Samples collected for organic analysis shall be immediately placed into an iced sample cooler to prevent the loss of volatile compounds. Soil samples acquired for metals analysis will be collected by placing an aliquot of soil into an appropriate glass sample container. Sample container requirements are described in the previously approved Quality Assurance Project Plan (QAPP).

To prevent cross-contamination between samples, the sampler shall wear disposable latex gloves during the collection of the samples. The sampler shall don a new pair of disposable gloves before collecting each sample. Also, the sampler shall decontaminate the sampling devices prior to each use. Decontamination procedures are discussed in the QAPP.

Following completion, each boring will be grouted with granular bentonite to surface and hydrated. Each boring will be sealed at the surface with concrete or asphalt. Soil cuttings will be containerized in 55-gallon DOT-approved drums and stored for subsequent disposal as discussed in the QAPP. Any decontamination liquids generated will be disposed of at the IWTP.

4.1.2 Groundwater Sampling

The groundwater samples will be collected during the Geoprobe investigation using the "Screen Point 15" Method. This method employs a Schedule 80 PVC screen that is sealed inside of a 1.5-inch ID alloy steel sheath as it is driven to depth. The screen is sealed inside the sheath with Neoprene O-rings which prevent infiltration of formation fluids until the desired depth is attained. When the screen has been driven to the interval of interest in the formation, extensions are used to hold the screen in position as the rods are retracted approximately 4 feet. A total of 41.5 inches of slotted screen is placed into contact with the formation. The Screen Point 15 has a total boring diameter of 1.5 inches while the outside diameter of the screen is 1.0 inches. This design allows a maximum of only 0.25 inch between the screen and natural formation as the sampler sheath is retracted. These conditions approach the ideal for natural formation development which can be conducted when lower turbidity samples are required.

After the screen is placed at the desired depth, the water in the screen point will be purged of a minimum of three volumes and until pH, temperature, and conductivity have stabilized. The purging process will be accomplished using either a peristaltic pump (with new dedicated tubing) or a new dedicated bailer. Upon completion of the purging process, the groundwater samples will be collected using either the peristaltic pump (inorganics only) or the dedicated bailer (organics).

4.2 Monitoring Well Installation Procedures

Monitoring wells will be installed in accordance with standard hollow-stem auger (HSA) drilling methods using 8 1/4-inch (or 4 1/4-inch) internal diameter (ID) hollow-stem augers. Prior to drilling at the initial and all subsequent borings, ancillary rig equipment will be cleaned using a high pressure cleaner wash at the temporary on-site decon station to eliminate cross-contamination between successive drilling locations.

During the monitoring well installation process, soil samples will be collected at select locations/ intervals for field screening, lithographic description, and potential chemical analysis. Soil samples will be collected using either a Lasky (5' x 4") core barrel or a split spoon (2' x 2") sampler. Each sampler will be opened and immediately scanned with a PID and/or FID to identify potential presence of VOCs. To maintain lithographic descriptive consistency, each soil sample will be described and classified in accordance with the Unified Soil Classification (USC) system.

Each monitoring well will be installed in accordance with the QAPP and the following general protocols:

1) Each monitoring well (except for MW-7S) will be constructed of 2-inch diameter PVC with flush-threaded joints. Monitoring well MW-7S will be constructed of 4-inch diameter stainless steel. Ten foot screen length sections (0.010-in slot) will be installed within each well.

2) The artificial sand pack will consist of chemically inert, rounded, silica sand and will be placed to a height of approximately two feet above the top of the screen.

3) A bentonite pellet seal three feet in thickness will be placed above the sand pack material.

4) The annular space above the bentonite pellet seal will be sealed with cement/bentonite grout.

5) Each monitoring well will be completed with a flush-mounted, water-tight protective casing.

6) Well construction details will be recorded on standard field forms.

Special installation procedures will be utilized for MW-8D (and any other deep wells that are installed to the bedrock surface) to ensure that cross-contamination does not occur between the shallow and deep saturated units. The deep well(s) will be constructed by using 8-1/4" I.D. hollow stem augers to set a 10-inch casing at an approximate depth of 60 ft bls. The casing will be grouted from the bottom of the casing to ground level. After the grout has set, the boring will be advanced to total depth (approximately 70 ft bls) using 4-1/4" I.D. hollow stem augers.

After installation, all monitoring wells and piezometers will be developed to ensure that particulate matter introduced into the formation from the drilling process is removed, and to ensure good hydraulic connection with the formation. Formation water and fines will be evacuated throughout the water column. A bailer or submersible pump will be moved up and down throughout the water column in the screened portion of the well to maximize water flow through the entire screened length. A surge block may be used to facilitate flow of water into the formation between withdrawal periods.

Development procedures will be continued until one of the following criteria is met:

- Removal of a minimum of three well casing volumes or until the well is dry; or
- Stabilized measurements of pH, temperature, and specific conductance are recorded (e.g. consecutive field readings within 10 percent of each other).

4.3 Field Screening and Sample Selection Procedures

Each soil sample will be screened in the field with a photoionization detector (PID) for total organic vapors (TOV) by the headspace method. This will involve placing a portion of the soil sample into a resealable plastic bag or similar container and allowing time for volatilization, if any, to occur. The concentration of VOCs that partition from the soil to the gaseous state are then recorded in parts per million (ppm) by placing the PID probe into the container headspace.

The PID will be calibrated at a minimum of once per day during the RFI field effort. Instrument calibration will be performed in accordance with the manufacturers' recommended procedures using either commercially available or laboratory-provided calibration standards. All calibration data will be recorded in the Field Equipment Calibration Logbook.

4.4 Sample Collection Procedures

Samples will be collected and submitted for off-site chemical analysis of nine selected VOCs according to the target constituent list identified for SWMU No. 17. The proposed analytical parameters were selected based on RFI results and knowledge of chemical usage for SWMU No. 17.

4.4.1 Soil Sampling

Soil samples will be collected from selected borings/intervals for lab analysis using the 4-ft Macro-Core Geoprobe sampler, Lasky core barrel, or split spoon sampler. In the event that coarse gravel fill material is encountered below the concrete and collection of sufficient soil volume is not possible, the borings will be advanced until finer-grained materials (e.g. sand, silt or clay) are encountered, and the sample then collected.

The results of the field screening (PID, visual observation) will be utilized in the selection of sample intervals. The sample with the highest TOV level will be submitted for chemical analysis. Visual observations by the field geologist will also be considered in the sample selection process. Refer to Section 3.4 for SWMU-specific screening criteria and anticipated sample depths.

4.4.2 Groundwater Sampling

Water level measurements will initially be performed using an electronic water level probe and measured to the nearest 1/100 foot. Data will be recorded in a field notebook and subsequently transferred to a standard monitoring form.

Prior to the collection of groundwater samples, each monitoring well will be purged using a downhole submersible pump or a disposable polyethylene bailer. Each monitoring well will be purged by removing a minimum of three well casing and sand pack volumes of groundwater and obtaining stabilized field parameter readings, or until dry. If groundwater is turbid after completion of the well purging process, the silt/clay particulates will be allowed to settle prior to initiating sample collection activities. A settling period of 1-6 hours is anticipated. Groundwater will subsequently be sampled/collected from the top of the water column. These measures will serve to minimize sample turbidity, thus enhancing the accuracy of the associated analytical results.

The following collection procedures will be observed when using a bailer to sample a groundwater monitoring well:

- Lower the bailer slowly to the interval from which the sample is to be collected.
- A determined effort will be taken to minimize disturbance of the water column when raising and lowering the bailer in order to prevent aeration of the water column.
- Sample bottles will be filled by allowing the water to flow out the valve in the bottom of the bailer and into and along the side of the sample bottle.

The following constraints will also be observed when using a bailer:

- Only bottom-filling HDPE bailers or bailers made of other inert materials will be used.
- Only unused, decontaminated, or dedicated bailer line will be used.
- A reel upon which the bailer line may be wound is helpful (but not required) in lowering and raising the bailer. It also reduces the chance of contamination.

4.4.3 DNAPL Sampling Considerations

Screening methods (interface probe and visual observation) will be utilized to evaluate the presence of potential DNAPL during the supplemental investigation (for monitoring well MW-7S in particular). For any locations that indicate the presence of DNAPL, additional sample collection procedures will be implemented. If feasible, a dedicated bailer or submersible pump will be used to collect a DNAPL sample. The DNAPL sample will be submitted to an off-site laboratory for product fingerprint analysis.

4.5 Quality Assurance/Quality Control Samples

In accordance with the previously approved QAPP, one duplicate soil sample will be collected and analyzed per twenty soil samples. The soil duplicate samples will be analyzed for the target list of VOCs. Similarly, one duplicate groundwater sample will be collected for each quarterly groundwater monitoring event and submitted for off-site lab analysis.

4.6 Sample Management, Preservation, and Chain-of-Custody Procedures

Upon collection, each sample will be managed according to the procedures described in this subsection. These procedures have been established in accordance with the QAPP. Appropriate USEPA analytical methods, sample preservation techniques, sample volumes, and holding times are also presented in the QAPP.

4.6.1 Sample Containers

Samples will be collected into sample containers which have been pre-cleaned and assembled to USEPA's Protocol "B". The volume of sample collected and the type of container used will be determined by the suggested volumes described in SW-846 for the particular analysis. A summary of the bottle requirements and sample volumes is included in the QAPP.

4.6.2 Sample Management

Immediately upon collection, each sample will be properly labeled to prevent misidentification. The sample labels will include the sample number, the sample location, the sample depth, the date sampled, the time sampled, the analyses to be performed, and the sample collector's name. The sample labels will be affixed to the sample jar immediately upon collection. The sample labels will be made of waterproof material and filled out with waterproof ink.

After labeling, the samples will be placed into an appropriate shipping container. Samples collected for organic analysis will be placed into a shipping container with sufficient ice or ice packs to maintain an internal temperature of four-degrees (4°) Celsius during transport to the laboratory. The samples will be appropriately packaged in the shipping container to minimize the potential for damage during shipment. A completed chain-of-custody form will be placed in each shipping container to accompany the samples to the laboratory. The shipping containers will then be sealed with several strips of strapping tape.

The sample containers will be shipped via overnight courier (such as Federal Express) to the designated off-site laboratory. Samples will be shipped so that no more than 24 hours elapse from the time of shipment to the time the laboratory receives the samples. The method of sample shipment will be noted on the chain-of-custody forms accompanying the samples. Strict chain-of-custody procedures will be maintained during sample handling.

4.6.3 Preservation

Samples for organic analyses will be preserved by placing each sample immediately into a cooler with sufficient ice or ice pack material to maintain a temperature of 4-degrees (4°) Celsius or less during transport to the laboratory. Sample preservation is not required for soil samples collected for metals analysis. Hydrochloric and nitric acid will be added to groundwater samples that are being analyzed for VOCs and metals, respectively. The required sample preservation methods for the specific constituents are included in the QAPP.

4.6.4 Chain of Custody

A chain-of-custody program will be followed to track the possession and handling of individual samples from time of collection through completion of laboratory analysis. Copies of the chain-of-custody record will be retained in the permanent file for proper documentation. The chain-of-custody forms shall include at a minimum:

- Sample number;
- Date and time of collection;
- Sample type (e.g., soil, groundwater, etc.);
- Parameters requested for analysis;
- Signature of person(s) involved in the chain of possession; and
- Inclusive dates of possession.

4.7 Analytical Methods

The samples will be submitted to a qualified off-site laboratory for analysis. Sample analyses shall be conducted for nine selected VOCs (benzene, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,2-trichloroethane, TCE, vinyl chloride, and methylene chloride) as previously described in Section 3.4. Lab quality assurance/quality control procedures will comply with the requirements of the QAPP.

4.8 Aquifer Test Procedures

4.8.1 Pump Test Procedures

A short-term pump test will be performed to evaluate hydraulic conductivity, transmissivity, hydraulic interconnection, and other hydrogeological properties of the saturated unit within the source area. This data will be used with gradient information to determine groundwater flow velocities. The test will be conducted using a Grundfos submersible pump to extract groundwater from the designated monitoring well location. Resulting water levels will then be measured at adjacent monitoring wells/piezometers. The duration of the pump test will be determined in the field based upon the water level changes for the adjacent piezometers/monitoring wells.

4.8.2 Slug Test Procedures

If groundwater recovery at MW-7S is insufficient to complete the previously described pump test, an aquifer slug test may be performed to evaluate the hydraulic conductivity of the water-bearing unit.

The slug test would be performed by lowering the water level in monitoring well MW-7S, then monitoring the rate of groundwater recovery. A plastic slug will initially be inserted into the water column. Then, water levels will be allowed to equilibrate prior to removing the plastic slug. The associated response time for each well will be recorded using a data logger equipped with a calibrated transducer. Water levels will be recorded to the nearest 0.001 foot and referenced to the top of each well casing.

4.9 Equipment Decontamination Procedures

All drilling and sampling equipment will be decontaminated prior to initial use at the Facility. Decontamination of Geoprobe equipment and other pieces of equipment will be performed at the drilling locations. Rinsewaters will be collected into a bucket or drum.

To prevent possible cross-contamination between samples, all down-hole drilling tools and sampling equipment will also be decontaminated between boring locations. Decontamination procedures for sampling equipment will consist of a wash of an Alconox solution, a potable/tap water rinse, followed by a distilled water rinse.

4.10 Waste Collection and Disposal Procedures

Waste materials derived from the field investigation, such as drill cuttings, decontamination rinsewaters, and personal protective equipment, will be collected in DOT-approved 55-gallon drums. The collected waste materials will be segregated into drums based on waste medium (water, soils, etc.). Each drum will be clearly labeled to indicate the type and approximate volume of contents, source, accumulation start date, and signature of the person completing the label.

The drums will be stored at an on-site location that will not disrupt Facility activities, yet provide a sufficient degree of security to deter any tampering with their contents. Equipment decontamination rinsewaters will be transferred to the influent of the IWTP where they will be treated to meet discharge standards in a similar manner with the chemical process influent. Drums with solid materials will remain on-site until proper disposal arrangements are completed by Boeing.

8.0 REFERENCES

The following list includes references cited in the text and general references used in the preparation of the RFI Workplan Addendum that were not specifically cited in the text.

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Missouri Department of Natural Resources, Part I RCRA Permit, USEPA ID No. MOD000818963, March 5, 1997.

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United States Environmental Protection Agency, USEPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, USEPA QA/R-5, May 1994.

United States Geological Survey. 1984. Survey of Missouri, Geological Survey Professional Paper. 954-H, I.

Table 3-1. Summary of Supplemental Investigation Parameters, RFI Workplan Addendum, Boeing, Hazelwood, Missouri Facility

SWMU ID	No. of Borings	No. of Soil Samples	No. of New Groundwater Monitoring Points	No. of Groundwater Samples	Target Analytical Constituents	SW846 Method	Sample Selection Criteria	Projected Sampling Intervals	Investigation Method	Projected Boring Depth*	Comments
No. 17: Transfer Area for Recovered PCE	7-9	6	7 (6 monitoring wells & 1 temporary piezometer)	12 (for initial quarterly monitoring event)	9 VOCs; Geotechnical & Biodegradation Parameters	8240; N/A	VOCs: Highest PID &/or Visual Determination	Variable (see Section 3.4 for specific intervals)	Geoprobe and HSA	Variable 70 ft bls for deepest downgradient boring; 15 ft bls for source area borings; 25 ft bls for deepest upgradient boring.	Horizontal step-outs if PCE/VOC impacts are evident for the upgradient or downgradient borings.

* Vertical delineation depth subject to field modifications.

FIGURES

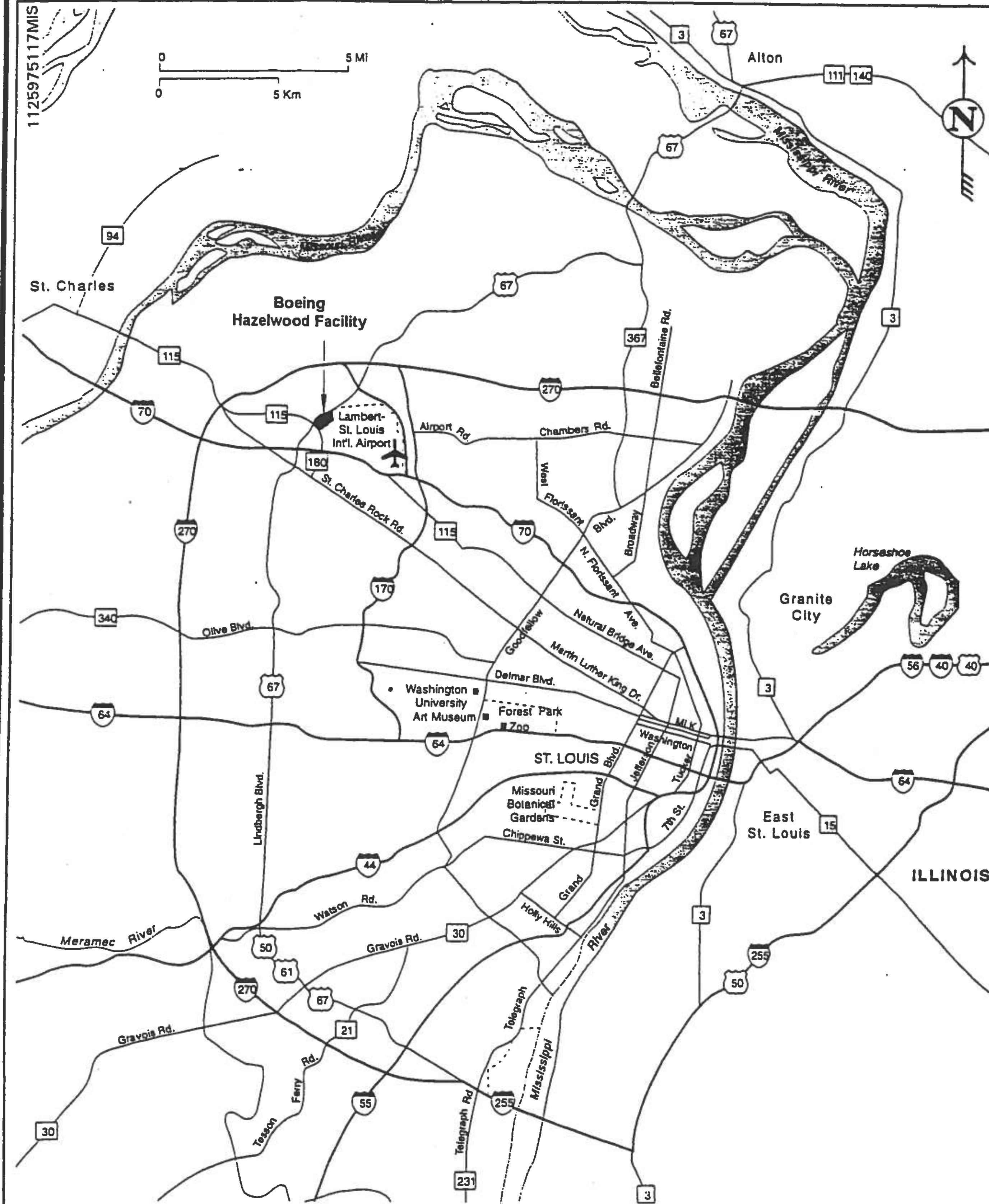

Figure 1-1
FACILITY LOCATION MAP
BOEING FACILITY
HAZELWOOD, MO

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Building No.	Description
20, 30A	Electrical Substation & Pump House
22	Garage Building
23	Cooling Tower
24	Pedestrian Underpass (East)
25, 25A	Wind Tunnel (Low Speed) Unit Substation
25B	V/STOL Test Facility
26	Pump House (Fire Protection)
26A	Storage Tank (Fire Protection)
27	Manufacturing Building
28	Fuel System Laboratory
29	Fabrication Building
29A	Composites Manufacturing

1	Administrative Offices
2	Manufacturing Building
3	Office Annex Building
4	Office Building
5	Boiler House
5A, B	Sprinkler System Storage Tank
6	Maintenance Building
7	Gate House
19	Compass Rose
40	Ramp Service Building
41	Chemical Storage Building
42	Production Hangar
43	Ramp Utilities Building
43A, B, C, D	Storage Tanks (Ramp H_2O & Air Serv.)
44	Pump House (Fire Protection)
45	Production Hangar
45A, B, F, G	Ramp Shelters
45C, D, E, L	Hush Houses
45J	Radar Cooling Equipment Building
45K	Fuel System Work Facility
45L	Hush House #4
46	Fuel-Filter Building
48	Ramp Paint Booths
49, 49A	Water Check Facility
51	Manufacturing Building
52	Manufacturing Building
53	Boiler House
55	Service Building
55A	Storage Building
56	Boiler House

Building No.	Description
30, 30A	Pedestrian Underpass (West)
32	Office Building
33	Office Building
34	Office Building
39	Chemical Storage Building
211, 214	Guard Shelters
215	Bus Shelter (McDonnell Blvd.)
216	Die Storage Rack
220	Composites Manufacturing
220A	Unit Substation
221	Office and Engineering Laboratories

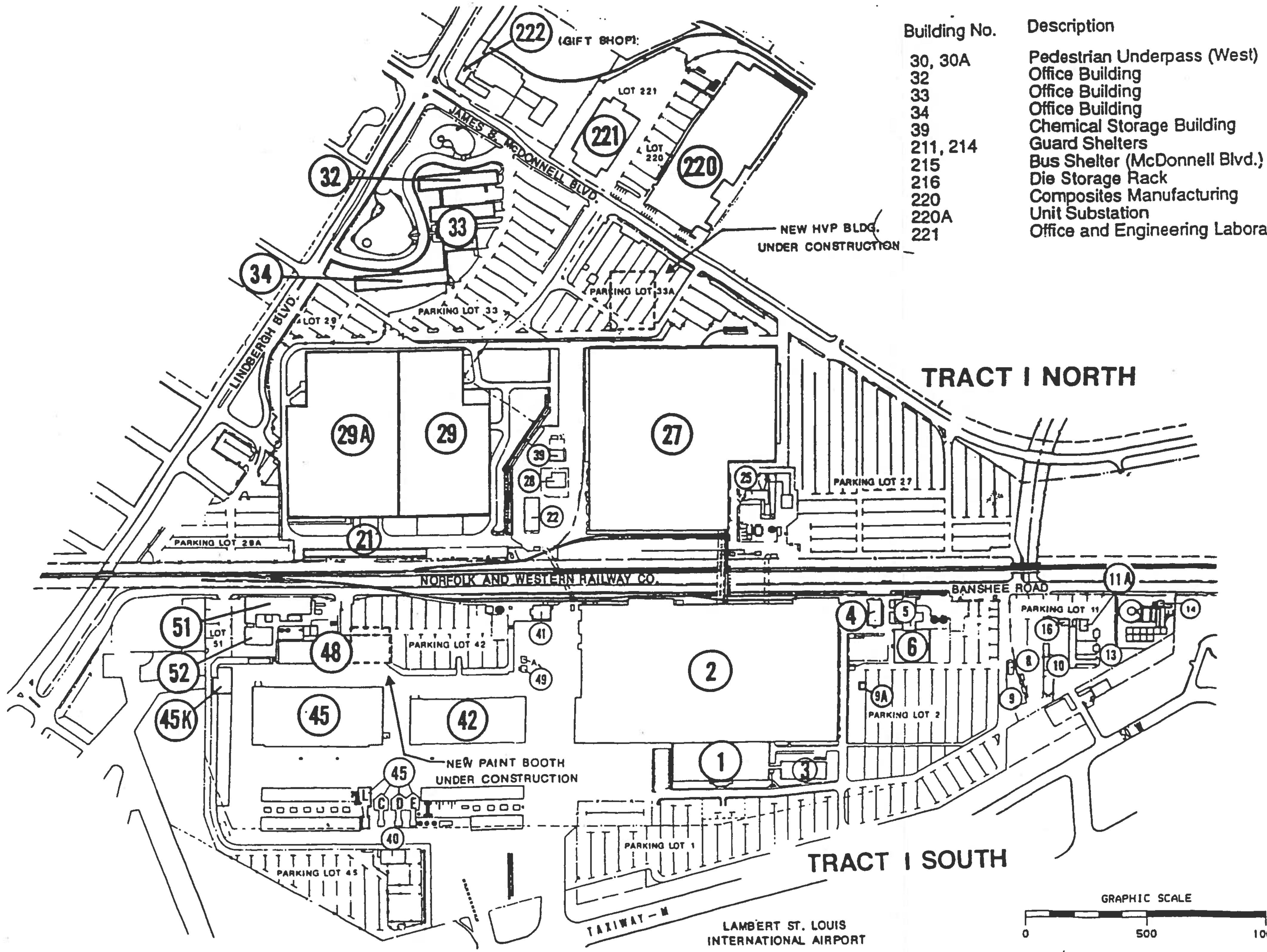

Figure 1-2
LAYOUT OF FACILITY AND SWMU LOCATIONS
BOEING FACILITY
HAZELWOOD, MO

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REVISED RFI SCHEDULE

	Start Date	Duration (Days)	End Date
Submittal of RFI Workplan Addendum to MDNR	3/17/00	1	3/17/00
Receive Authorization to Proceed & Mobilization Time	4/10/00	21	5/1/00
Field Investigation	5/1/00	5	5/5/00
Laboratory Analysis	5/8/00	30	6/6/00
Quarterly Groundwater Monitoring	5/4/00	1	2/1/01
Internal Revised RFI Report Prepared	3/1/01	45	4/15/01
Boeing Review of Revised RFI Report & Submittal to MDNR	4/16/01	15	4/30/01
Revised RFI Report Reviewed & Comment by MDNR	5/1/01	90	8/1/01

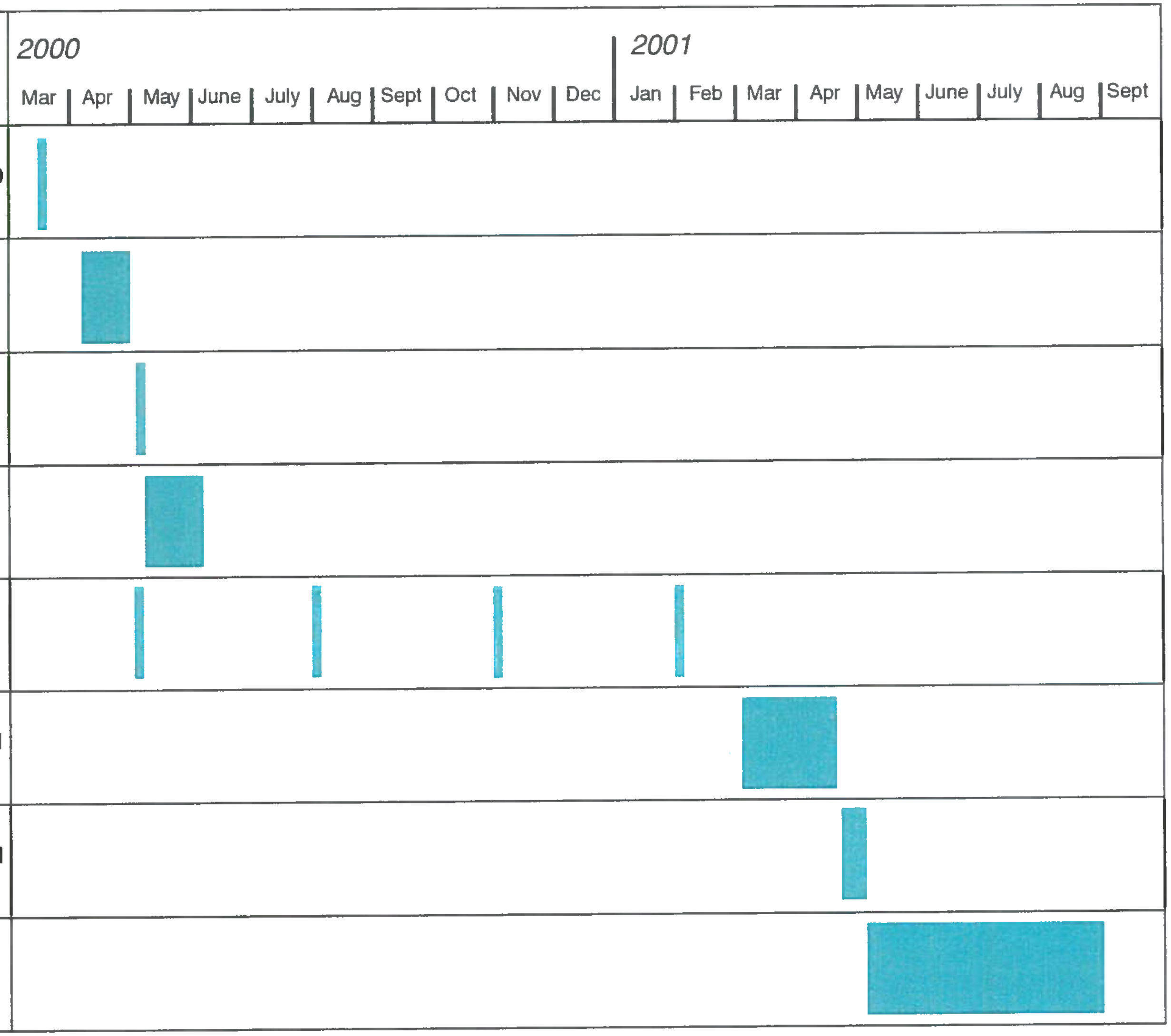

Figure 2-1
REVISED RFI SCHEDULE
RFI WORK PLAN ADDENDUM FOR BOEING
HAZELWOOD, MISSOURI FACILITY

Environmental Science & Engineering, Inc.
A MACTEC Company

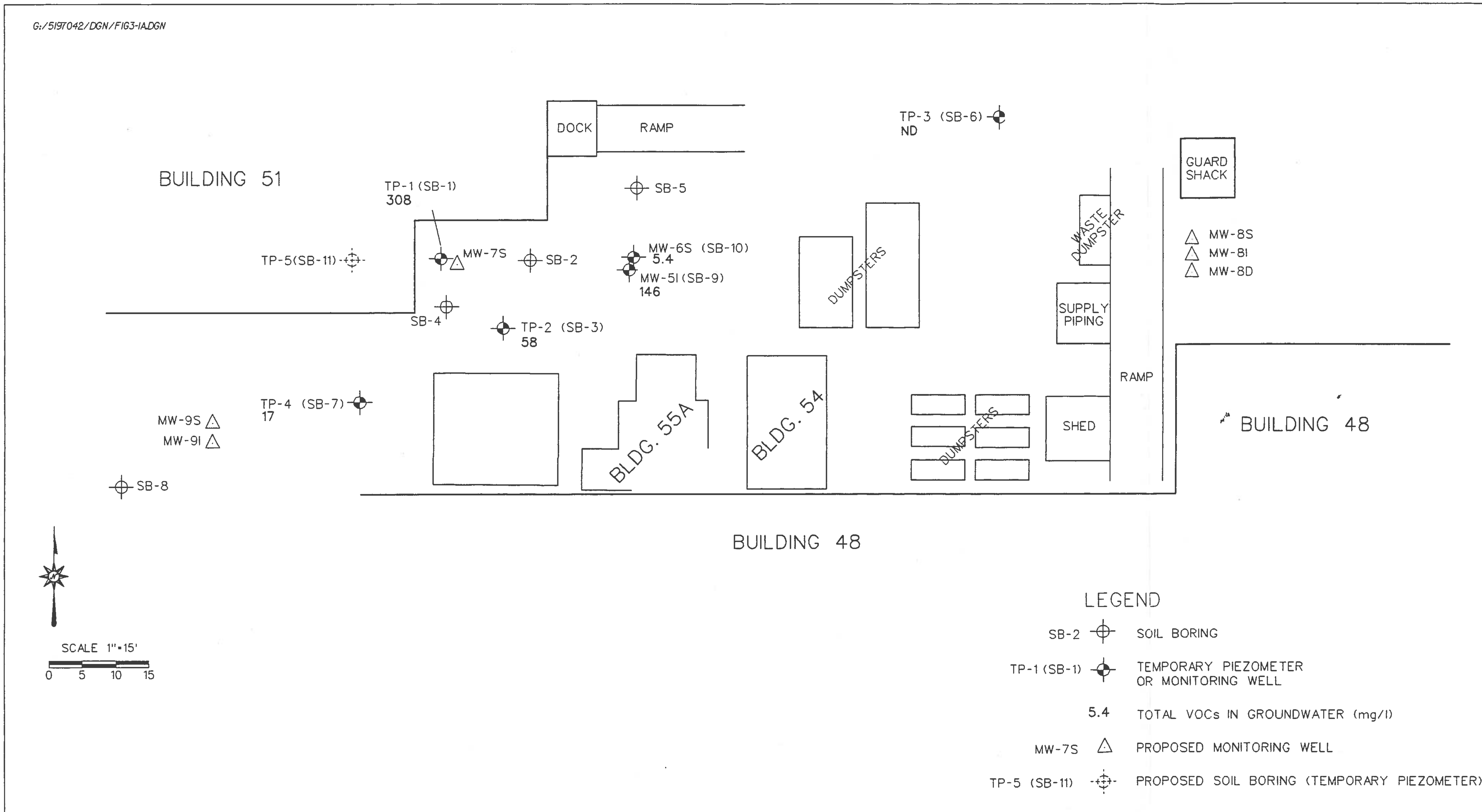

Figure 3-1
PROPOSED SOIL BORING AND MONITORING WELL LOCATIONS FOR SWMU No. 17
BOEING FACILITY
HAZELWOOD, MO

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